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User Guide: How to Use and Operate Virtual Reality Equipment in the Systems Assessment and Usability Laboratory (SAUL) for Conducting Demonstrations

by Michael N Geuss and Joseph A Campanelli

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User Guide: How to Use and Operate Virtual Reality Equipment in the Systems Assessment and Usability Laboratory (SAUL) for Conducting Demonstrations

by Michael N Geuss and Joseph A Campanelli
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14. ABSTRACT The goal of this user's guide is to provide the novice virtual reality user with step-by-step directions to use multiple commercially available virtual reality systems. Specifically, this guide will cover how to implement demonstration software for an L-shaped projection screen, an Oculus Rift head-mounted display, an HTC Vive head-mounted display, and a combination of the L-shaped projection screen and head-mounted displays. Common issues will be noted and troubleshooting solutions will be provided.					
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1. Introduction

The goal of this user's guide is to introduce the reader to basic virtual reality hardware/software and functionality and to present step-by-step directions for how to operate the virtual reality system located in the Systems Assessment and Usability Laboratory (SAUL). Using this guide, a novice user with no virtual reality experience should be able to operate WorldViz^{*} and Unity3D[†] demonstrations, set up multiple displays (e.g., simultaneous use of projection screen and Oculus Rifts[‡]), and be able to solve common operating problems. For deeper insight into creating content within the virtual environment, WorldViz and Unity 3D provide open access guides to more complicated processes (see bibliography).

While many of the details herein are specific to the individual setup located in the SAUL, broader lessons can be learned for systems using similar hardware and software but with different configurations. The virtual reality systems located in the SAUL, as of June 2017, include 4 desktop computers, 3 HTC Vives,[§] and 3 Oculus Rift head-mounted displays (HMDs) with built in tracking systems, an L-shaped screen setup with 2 projectors, and WorldViz's Precision Position Tracking (PPT) system.

For demonstrations using the Oculus Rift or L-Shaped projection system, users need to use PPT Studio, Vizard 5,^{*} and Cluster Master/Client^{*} (for multiple users). The PPT system allows 6 degrees of freedom (DOF) tracking (orientation and position) and includes both the PPT Studio N software and 8 tracking cameras that retrieve position information from Markers (Fig. 1). Vizard 5 is a scripting program that calls premade 3-D models of environments and can be edited to include many different functionalities. Cluster Master/Client allow the computers to communicate with each other and display the same virtual environment to multiple users. Cluster Master must be run on the computer running the Vizard 5 program. Cluster Client receives the data from the computer running Vizard 5.

For demonstrations using the HTC Vive HMD, SteamVR^{**} and a Unity3D program are required. SteamVR is an application that connects the HTC Vive HMD, controllers, and tracking hardware. Unity3D is a gaming engine that supports 3-D graphics, drag-and-drop functionality, and scripting. Unity VR allows for direct targeting of virtual reality devices. The tracking systems for the HTC Vive and PPT

^{*} WorldViz, 614 Santa Barbara St, Santa Barbara, CA, 93101.

[†] Unity Technologies, 30 3rd St, San Francisco, CA, 94103.

[‡] Oculus, 1601 Willow Road, Menlo Park, CA, 94025.

[§] HTC America, Inc., 308 Occidental Ave South, Ste 300, Seattle, WA, 98104.

^{**} Valve Corporation, PO BOX 1688, Bellevue, WA, 98008.

should not be on at the same time as they can interfere with each other. At this time, multiple HTC Vives cannot be run simultaneously using the same tracking environment.

This guide will cover, in order:

1. How to set up the PPT system.
2. How to implement the L-shaped projector for a single user.
3. How to implement the Oculus Rift HMD for a single user.
4. How to implement multiple Oculus Rift HMDs and the projector for multiple users.
5. How to run an in-house demonstration for a single user in the HTC Vive.

Throughout each section, we will cover common problems that arise (**Issues are indicated in bold**) and troubleshooting suggestions.



Fig. 1 WorldViz PPT Eyes (top), WorldViz wand (bottom)

1.1 Hardware List

- 1 × Lenovo^{††} Thinkstation w/NVIDIA^{‡‡} Quadro M6000 (PC 1)
- 3 × Lenovo Thinkstation w/NVIDIA GTX 1080 (PC 2, 3, 4)

^{††} Lenovo Group Ltd., Morrisville, NC 27560.

^{‡‡} NVIDIA, 2701 San Tomas Expressway, Santa Clara, CA 95050.

- 1 × L-Shaped Projection Screens
- 3 × Oculus Rift CV1 HMDs
- 4 × WorldViz PPT Eyes
- 4 × WorldViz Wand 2013
- 5 × Volfoni^{§§} 3DGE RF Shutter Glasses
- 1 × WorldViz Calibration Square
- 8 × WorldViz PPT Camera
- 3 × HTC Vive Kits
- 1 × Camera Switchbox
- 1 × LAN Switchbox

1.2 Startup Guide

1. Turn on necessary computers.
 - a. PC 1 is required to run PPT Studio N and the corner cave projection system.
 - b. PC 2–4 are capable of running the HTC Vive, Oculus Rift, and multiuser setups.
2. Connect power adapter to camera switch box.
3. Start PPT Studio N on PC 1, located on the desktop. If the cameras have not been activated, PPT Studio N must be restarted once they are receiving power.

1.3 Shutdown Guide

1. Turn off all computers.
2. Disconnect power adapter from camera switch box. This will help extend the life of the PPT cameras.
3. Turn off projectors if powered on.
4. Power off all other devices (i.e., wands, PPT Eyes, shutter glasses).

^{§§} Volfoni Creative 3D Technology, Los Angeles, CA.

5. Plug all devices into micro USB cables. Keep devices off the floor to minimize the possibility for accidents.
6. Wrap up HMD cords and place devices on an elevated surface.

2. How to Use PPT Studio

PPT Studio N software is installed on PC 1 and is WorldViz's solution for handling PPT camera input, tracking markers in 3-D space, and coordinating data transmission to LAN-connected PCs. PPT Studio N is necessary when using Vizard 5. The process to initializing PPT Studio N is as follows:

1. Locate and open the Desktop icon for PPT Studio N.
2. Load a .cfg file under File -> Load Settings (Fig. 1). The necessary .cfg files are located in the following sections.
 - a. Selecting a premade .cfg file in PPT Studio N loads active markers and plugins for a specific scenario into the tracking environment.
3. Turn on necessary hardware devices (minimum: one PPT Eyes for HMD or Shutter Glasses), by holding down the button on the devices.
4. Under the "Marker Visibility" section (Fig. 2).
 - a. A red marker number in the "Marker Visibility" section indicates that the markers are not detected by the tracking system. If red, double-check that the markers are switched on and in sight of cameras.
 - b. A green marker number in the "Marker Visibility" section indicates that the markers are actively tracked.

Note: The "MarkerID Plugin" errors that can be seen under "Messages" can be ignored. They do not seem to be indicative of any unusual behavior.

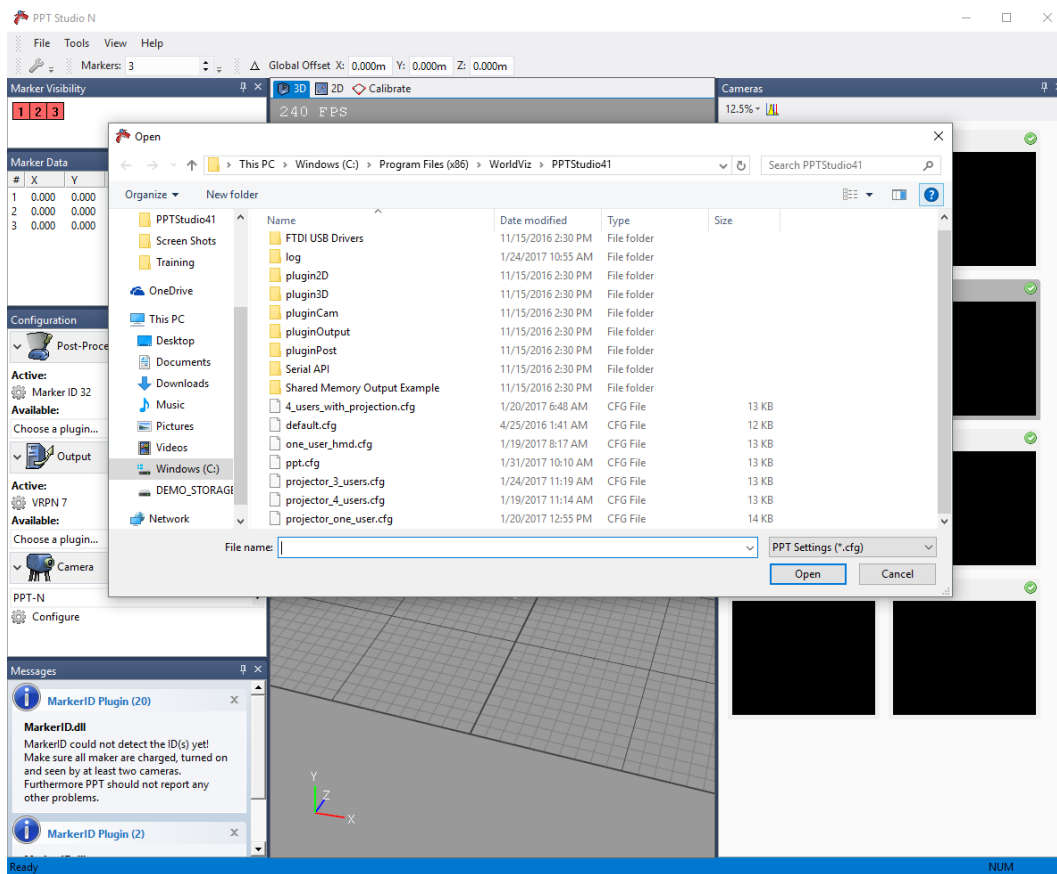


Fig. 2 Selecting Config files in PPT Studio

Issue: Markers are not being tracked, or tracking is jittery/not working as expected.

Potential Solutions:

- Ensure that marker devices (wands, bands, glasses) are fully charged and powered on. If on, there will be a green light on the PPT Eyes or marker wand.
- Check for occlusion (i.e., objects obscuring the camera's view). The door to SAUL can occlude the cameras, so make sure it is closed.
- Make sure that the HTC Vive base stations are either powered off or in standby mode. The base station laser array interferes with the PPT tracking system.
- Recalibrate the tracking system (see Section 2.1).
- Restart PPT Studio N and reload .cfg file.

Issue: Cameras show up red in PPT Studio N. This problem indicates that the cameras are not communicating with the PPT Studio N software (Fig. 3).

Potential Solutions:

- Check that a .cfg file is loaded into PPT Studio N.
- Ensure that camera switchbox is plugged in (look for the green light on the switchbox).
- Restart PPT Studio N.

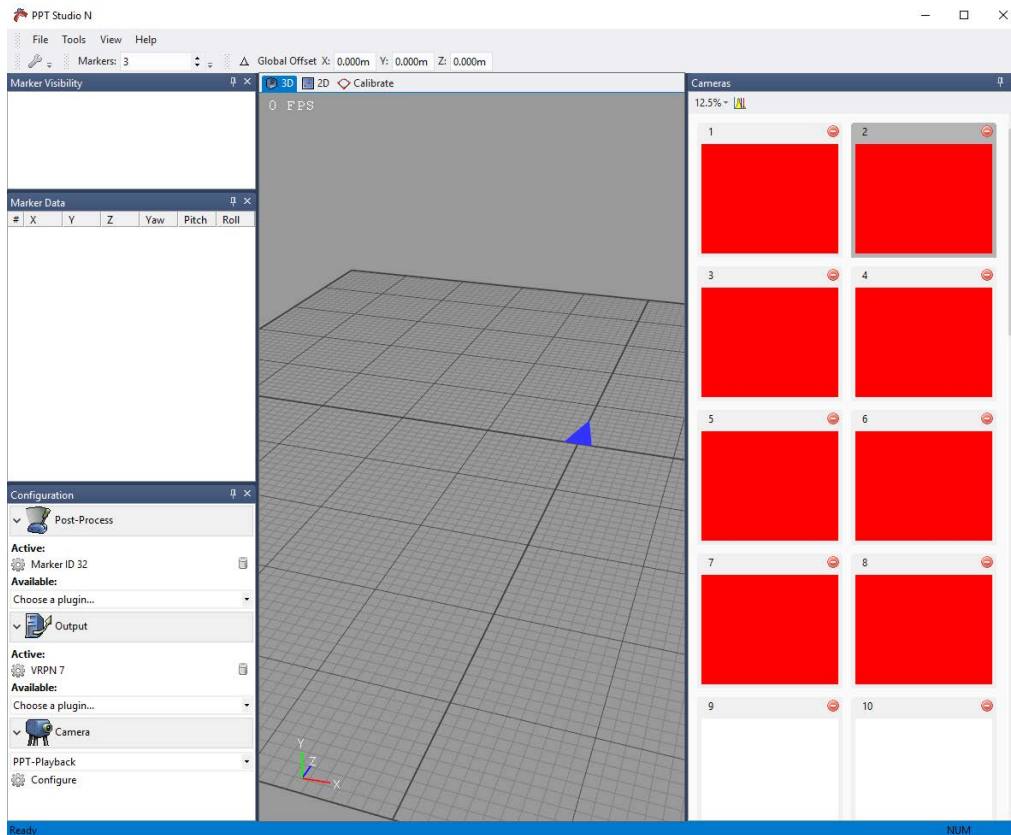


Fig. 3 Inactive cameras in PPT Studio N

PPT Calibration

Calibrating the PPT system should be done regularly (i.e., weekly) and is often the solution to unusual tracking behavior. This process is simple and described as follows:

1. Remove/power off all markers in the tracking space by holding down the power button.
2. Line up the calibration square with the tape on the center of the tracking space floor.

3. Position the square so that the Z-axis arrow is pointing directly away from SAUL entrance, and the X-axis arrow is pointing toward the wall to the right as you enter the lab doors.
4. Power on the calibration square by flipping the power switch.
5. Remove any objects occluding the camera's lines of sight.
6. Turn out the lights, as this can help the system to better track the markers.
7. Press the "Calibrate" button in PPT Studio. The "Calibrate" button is located at the top of the center window.
8. Follow the on-screen instructions to calibrate the PPT system.

3. Single User: Projector

The L-shaped projection screen can be used to display stereoscopic images. To view stereo images on the screens, each user needs to wear a pair of shutter glasses.

1. Start PPT Studio N (shortcut located on desktop) on PC1.
 - a. File -> Load Settings configuration file: "projector_one_user.cfg".
 - i. If another .cfg file is already loaded, PPT Studio N may need to be restarted before the new .cfg is loaded.
 - b. Make sure PPT Eyes Plugin is listed under the "Post-Processes" configuration box. If not, select it from the "choose a plugin . . ." option.
 - c. Power on PPT Eyes 1 by pressing the power button.
 - d. Power on Wand 1 by pressing the power button.
 - e. Markers 1 and 3 should be green under the "Marker Visibility" section in the top left box (Fig. 4). Marker IDs are hard-coded to specific PPT Eyes and Wands (Table 1).

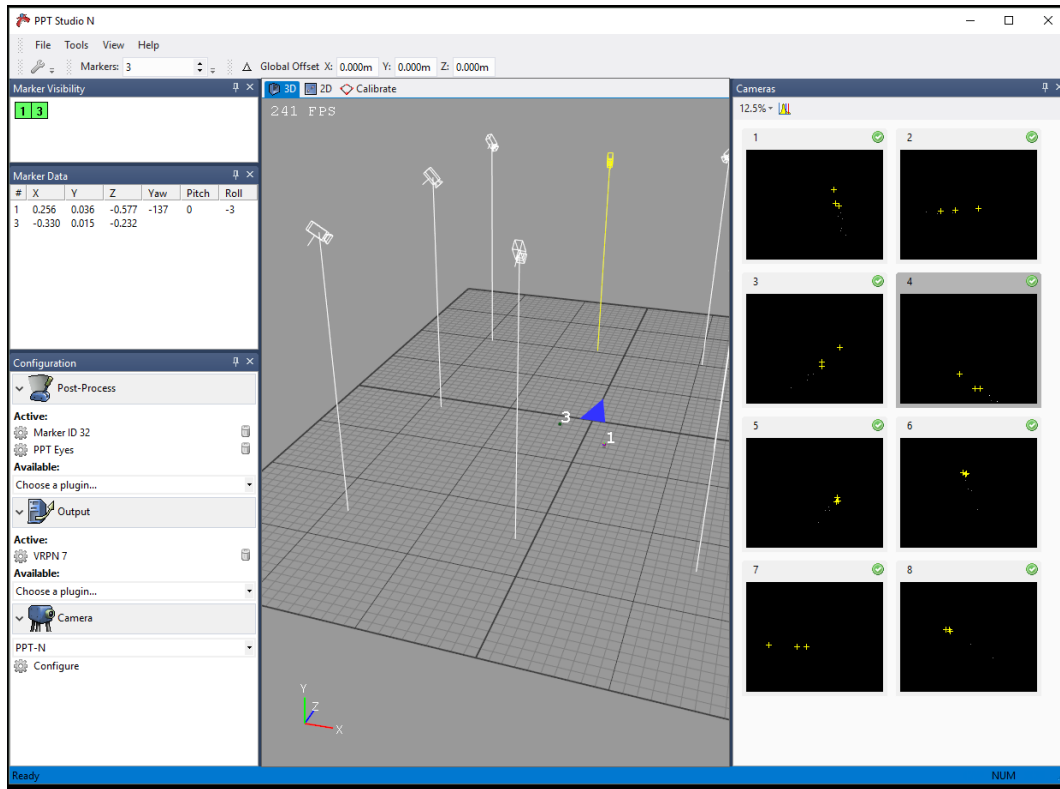


Fig. 4 PPT Studio N setup for projector

Table 1 Marker ID table

Device make	No. on device	Marker ID
Wand	1	3, (4)
Wand	2	7, (8)
Wand	3	11, (12)
Wand	4	15, (16)
PPT Eyes	1	1, 2
PPT Eyes	2	5, 6
PPT Eyes	3	9, 10
PPT Eyes	4	13, 14

Note: Marker IDs in parentheses are unused markers that are attached to the device.

2. Start Vizard 5 (shortcut located on desktop) on PC1.
 - a. File -> Open file: “demo_launcher64_via_vizard.py”. The demo launcher file can be found at “D:\Demo Launcher”.
 - i. This file starts an environment where all WorldViz demos can be accessed via a graphical user interface.
 - b. Press the Green Arrow on the shortcut bar to initiate the script (Fig. 5).

- c. Select a Vizconnect Configuration file from the pop-up menu that automatically opens when pressing the Green Arrow.
 - i. For a single user with the projection screen, select: “cave_vizconnect_config.py”.
- d. To calibrate the Wand, hold down the “W” button and the trigger button. This will bring the menu closer to your virtual hand.

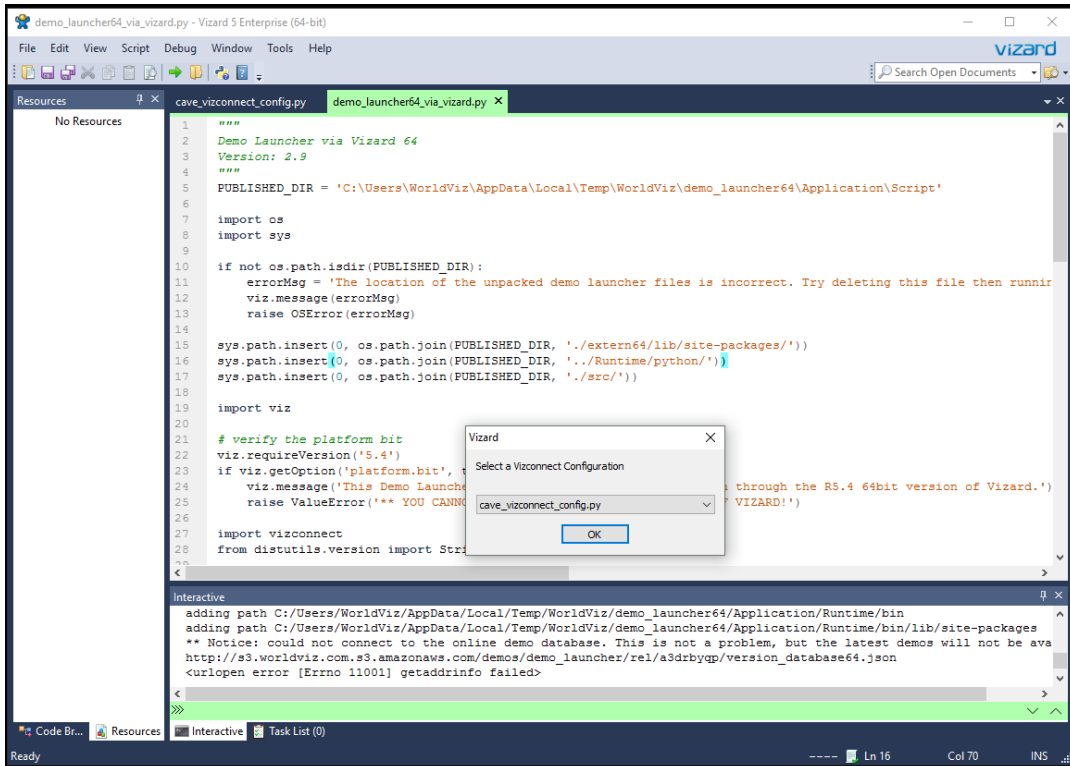


Fig. 5 Vizconnect Configuration selection

Issue: The displays do not work properly. This can appear as if the left image is on the right screen (or vice-versa), the image does not seamlessly span the 2 projectors, or an image is only being displayed on one screen. If any of these issues occur, check that the display settings are as follows:

- Under Windows Display Settings: There should be 2 displays active, with display “1” being the local monitor and display “2” being an elongated box referring to the 2 projectors (Fig. 6).
 - If not, utilize the NVIDIA Control Panel’s Mosaic function to set up multiple monitors.
- Under the NVIDIA Control Panel: Resolution should be 1280 × 720 and refresh rate should be 120 Hz (Fig. 7).

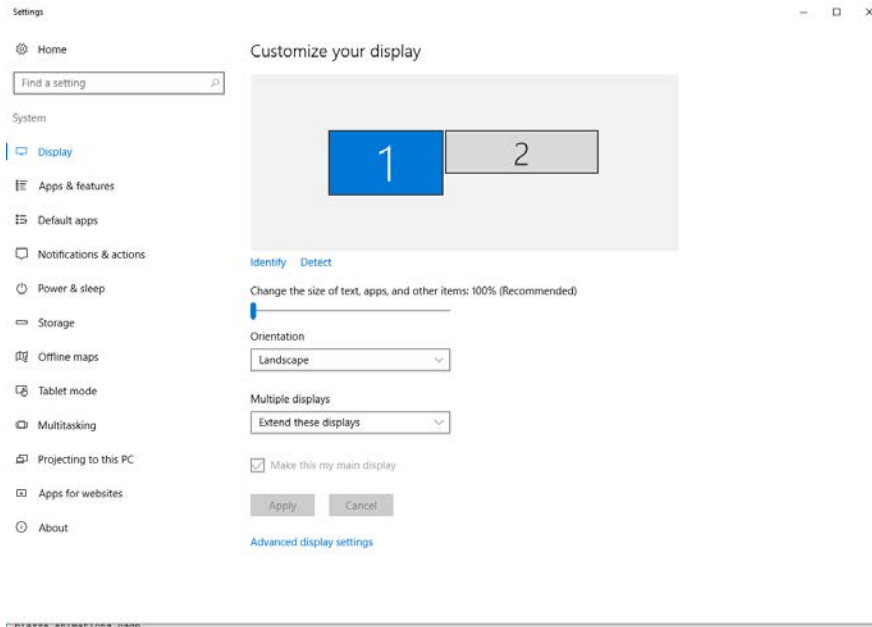


Fig. 6 Windows display settings

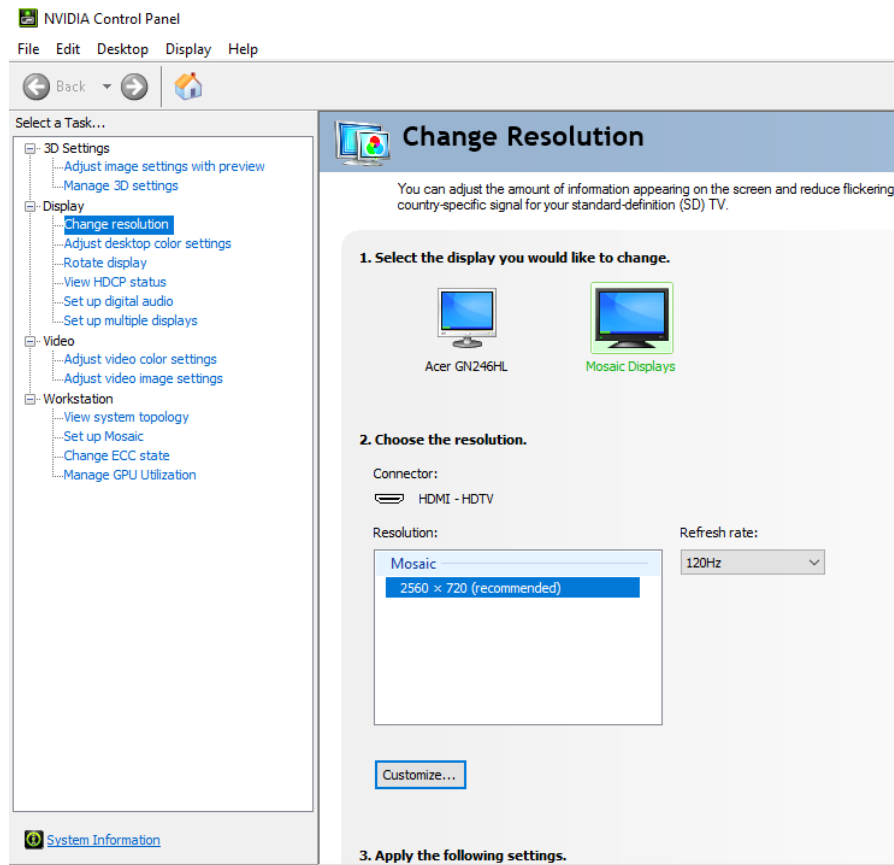


Fig. 7 NVIDIA control panel ideal setup

4. How to Set Up a Single Oculus Rift HMD User

WorldViz demos can also be viewed through the Oculus Rift HMD. This allows for a more immersive experience than the projection screen.

1. Start PPT Studio N (shortcut located on desktop) on PC1.
 - a. Load configuration file: “one_user_hmd.cfg”.
 - b. Power on PPT Eyes 2 by pressing the power button.
 - c. Power on Wand 2 by pressing the power button.
 - d. Markers 5, 6, and 7 should be green (Fig. 8).
2. Start Cluster Master (shortcut located on desktop) on PC2 and Cluster Client on PC1.
 - a. In Cluster Master: Select Local host and the IP of PC1.
 - b. In Cluster Client: Ensure “Enable” and “Show Me” are checked.

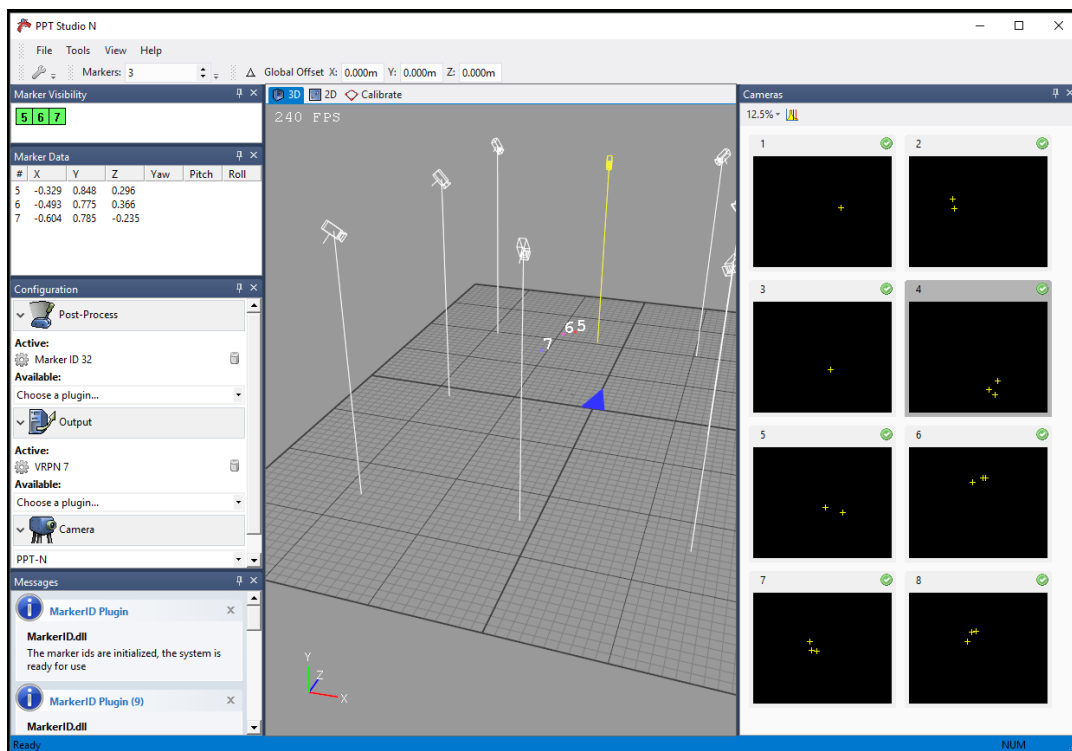


Fig. 8 PPT Studio N setup for HMD

3. Start Vizard 5 (located on the desktop) on PC 2.
 - a. File -> Open file: “demo_launcher64_via_vizard.py”.
 - i. This file starts an environment where all WorldViz demos can be accessed.
 - b. Press the Green Arrow on the shortcut bar to initiate the script (Fig. 9).
 - c. Select a Vizconnect Configuration file from the pop-up menu that automatically opens when pressing the Green Arrow (Fig. 9).
 - i. For a single user in the Oculus Rift HMD, select: “oculus_vizconnect_config.py”.
4. Confirm Oculus Rift Application is running (Fig. 10).
 - a. The Oculus application will automatically open when an Oculus Rift is detected on the computer. This must be running to activate the Oculus Rift HMD.

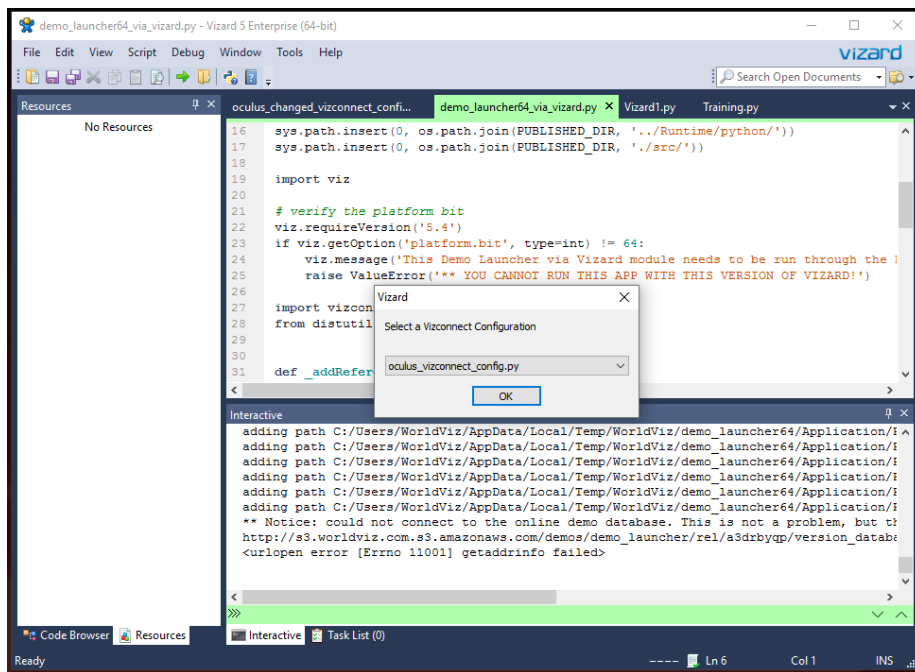


Fig. 9 Selecting Vizconnect configuration for Oculus Rift

Note: HMDs can only be run on PCs 2, 3, and 4.

Issue: The Oculus Rift is not receiving an image.

- Double-check that the Oculus Rift USB cable is plugged into a USB 3.0 port. USB 3.0 ports are the bottom ports on the back of the computers.
- Unplug the monitor cable and then plug it back in. This allows the graphics card to look for available displays.

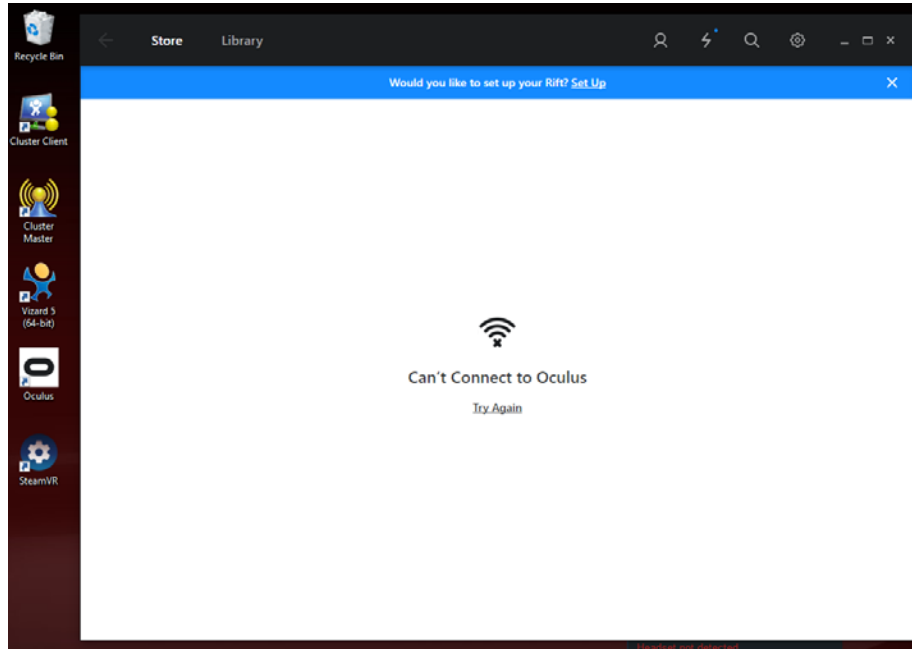


Fig. 10 Oculus Rift application

5. How to Set Up Multiple Users

Multiple users can view the same virtual environment. This can be set up with multiple Oculus Rift HMDs (up to 3) and one user viewing the projection screens. This setup, and any variation with multiple users, requires the Cluster Master and Cluster Client to be used.

Correct use of Vizard Cluster Master and Cluster Client is necessary to coordinate shared 3-D environments when using multiple users within the Oculus Rift or Multiple Users. Setting up a multiuser scenario is simple. The steps are as follows:

1. Start Cluster Master (Fig. 11) on your desired “host” PC (this is the PC you wish to run Vizard 5 from).
2. Start Cluster Client (Fig. 12) on as many additional PCs as you require.
3. Using Cluster Master/Client, you may edit additional parameters, such as avatar model, avatar color, and cross-user visibility.

- From the host PC, mark the checkboxes for each user that will be involved in the scenario.

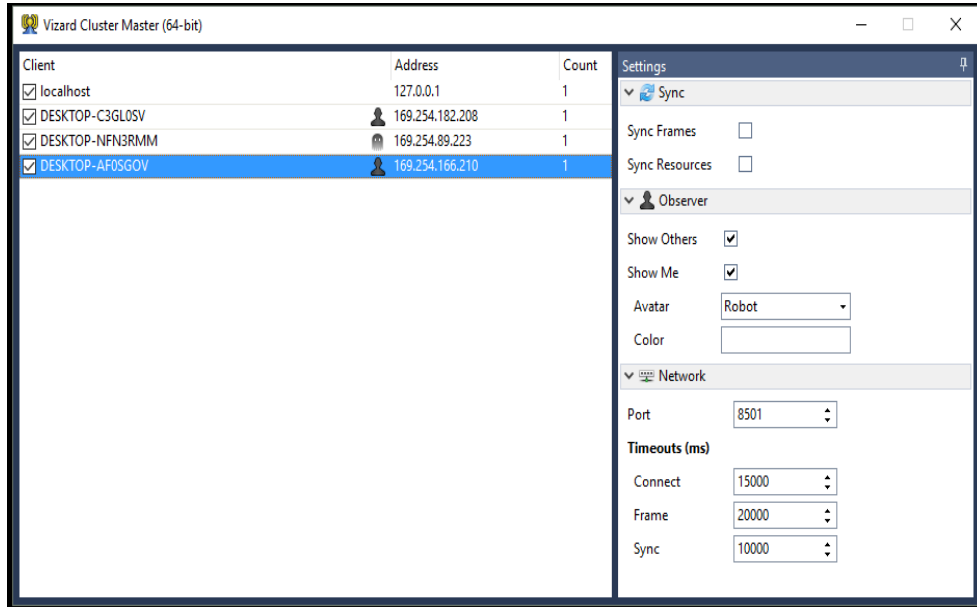


Fig. 11 Cluster Master running a 4-user setup

Note: The master machine will maintain synchronization among the client PCs, while also acting as a user in the virtual environment. Normally, it is best to set PC 1 as the master machine, but the setup can be configured for your particular needs.

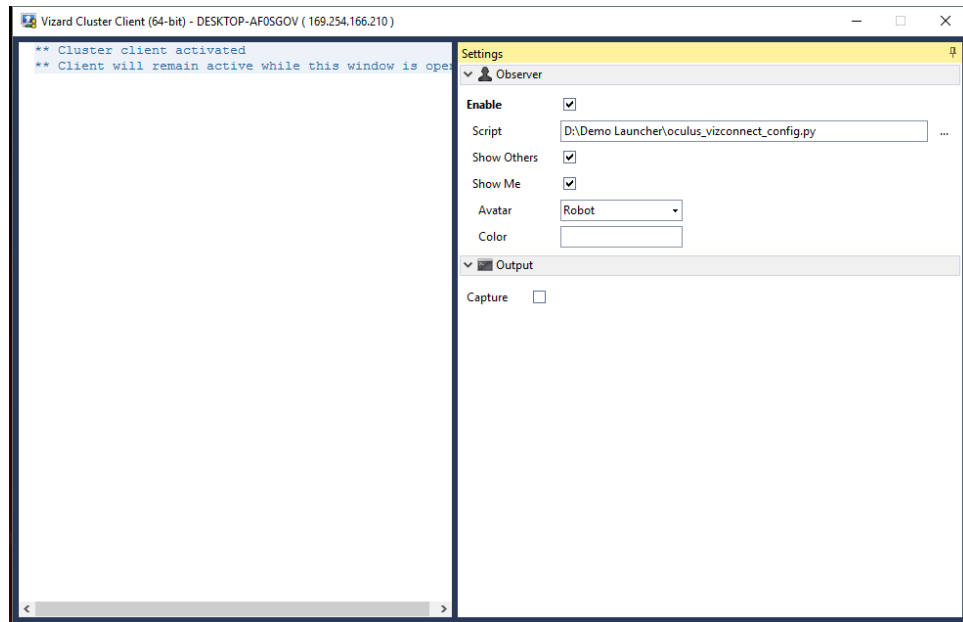


Fig. 12 Cluster Client running on PC with HMD

Issue: In the Cluster Master, the IP address must be highlighted in Red or the Cluster Master cannot connect to necessary computers (Fig. 13).

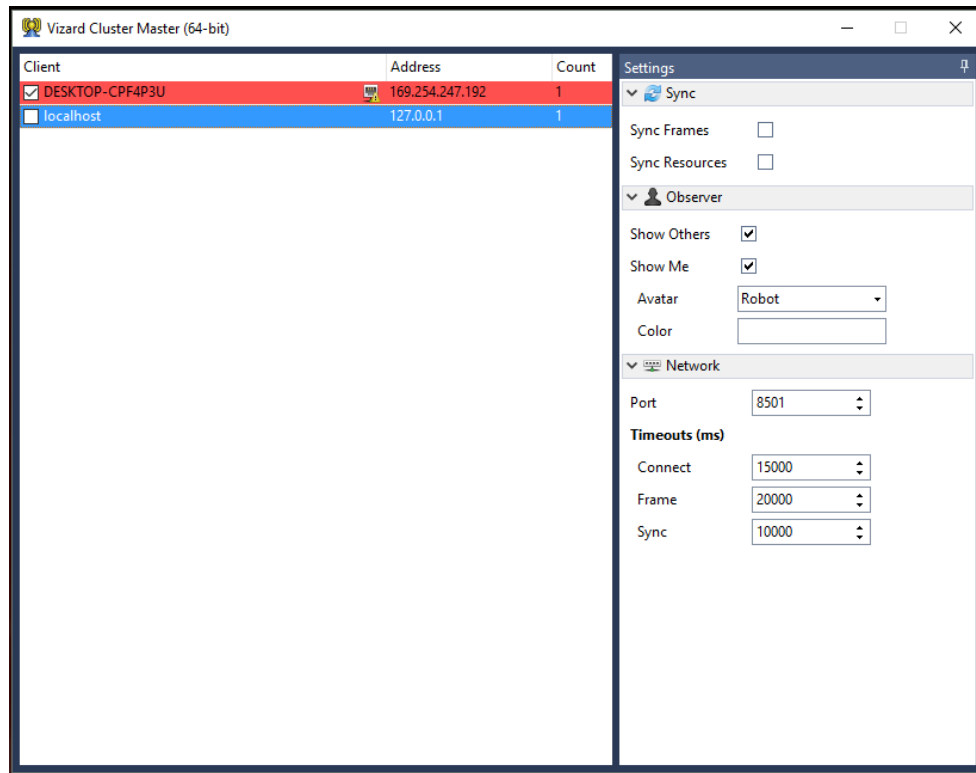


Fig. 13 Cluster Master unable to communicate with necessary computers

Potential solutions are as follows:

- Make sure that Vizard Cluster Client is open on the computer with IP address 169.254.247.192.
- Check that the LAN switchbox is powered on and all computers are connected.

One Projector and 3 HMD users:

1. Start PPT Studio N (shortcut located on desktop) on PC1.
 - a. Load configuration file: “projector_4_users.cfg”.
 - b. Power on all PPT Eyes by pressing the power button.
 - c. Power on all Wands by pressing the power button.
 - d. All Markers should be green (Fig. 14).
2. Start Cluster Master (shortcut located on desktop) on PC1 and Cluster Client on PC2, PC3, and PC4.

- a. In Cluster Master: Make sure that Local host, the IP for PC2, PC3, and PC4 are checked.
- b. In Cluster Client on all other PCs: Ensure “Enable” and “Show Me” are checked.
3. Start Vizard 5 (located on the desktop) on PC 1.
 - a. Load file: “demo_launcher64_via_vizard.py”.
 - i. This file starts an environment where all WorldViz demos can be accessed.
 - b. Press the Green Arrow on the shortcut bar to initiate the script.
 - c. Select a Vizconnect Configuration file.
 - i. For multiple users, select: “oculus_vizconnect_config.py”.
4. Confirm Oculus Rift Application is running on PC2, PC3, and PC4. The Oculus application will automatically open when an Oculus Rift is detected on the computer. This must be running to activate the Oculus Rift HMD.

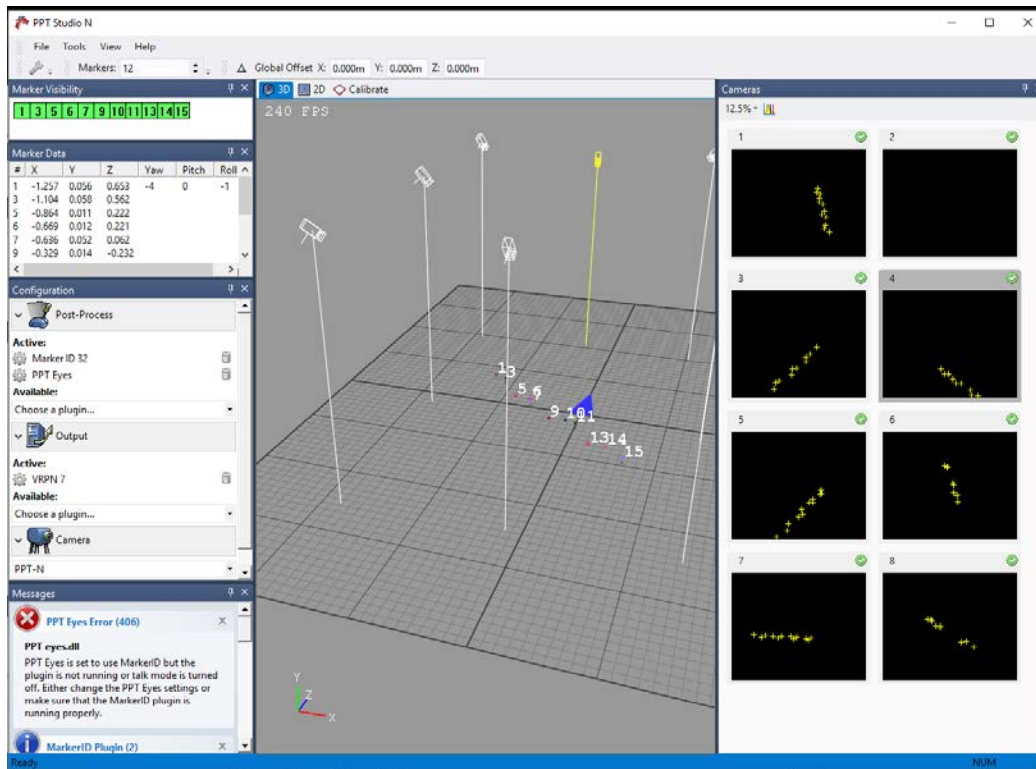


Fig. 14 PPT Studio N setup for 4 users

6. HTC Vive Setup

1. Connect HTC Vive to PC2.
 - a. HDMI Cable and USB from HMD should connect to the Connection Box.
 - b. From Connection Box to Computer: HDMI, USB, and Power cable should be connected.
2. Turn on controllers by holding the power button on the front for 5 s.
3. Position HMD and controllers in center of tracking area.
4. Double check that base stations are on (plugged in).
 - a. Powered on base stations are indicated by a green light shining within the box.
5. Run the SteamVR icon on the desktop.
 - a. All icons should be green (Fig. 15).
6. Open folder called “Build” located on the desktop of PC 2 and double click the build.exe file.
 - a. This will start the program where you can choose additional settings including resolution, mirror monitor, and quality of graphics.

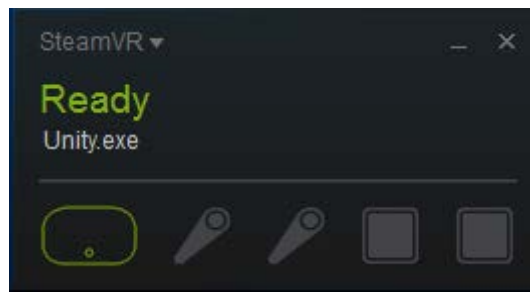


Fig. 15 SteamVR. When activated correctly, all icons appear solid green. When greyed out, like in image, turn on controllers, base stations, and ensure that the HMD is properly connected.

Issue: Base stations are blacked out.

Potential solution:

- Right click the base station icon seen in Fig. 15 and select “Reconnect”.

7. More Troubleshooting

Issue: Headset/wands not being tracked in Vizard, but they are tracking correctly in PPT Studio.

Potential solutions:

- Check that the Vizconnect file being used has the correct settings under “eyes left”, “eyes right”, and “r_hand_tracker”. There are 2 important settings: “ppt hostname” and “marker id”. The “ppt hostname” setting should correspond to the IP address of PC1 (which is running PPT Studio N), and “marker id” should correspond to that marker’s id (check marker id table for more information).
- Calibrate wand by pointing it toward virtual north, and pressing the trigger and clicking in the joystick at the same time.

Issue: Oculus Rift HMD is black/not showing a display.

Potential solutions:

- Restart the HMD’s connected computer.
- Unplug DVI cable from computer; keep HMD HDMI plugged in. Restart computer, then plug in DVI cable.
- Reboot Oculus software under Settings -> Beta -> Reboot.
- Ensure that Oculus Rift USB is plugged into a USB 3.0 port.
- Ensure that HMD outputs are properly seated in the computer ports.

Issue: When running a Vizard demo, the following message appears in the Vizard console: “(Make sure port name is valid and has not been opened by another program) Wand: input buffer not flushed”.

Potential solutions:

- Make sure that only one instance of Vizard is running on the computer at a time (e.g., Vizconnect editor and demo launcher are open, so they are competing for access to wand input).

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List of Symbols, Abbreviations, and Acronyms

3-D	3-dimensional
DOF	degrees of freedom
HMD	head-mounted display
LAN	local area network
PC	personal computer
PPT	Precision Position Tracking
SAUL	Systems Assessment and Usability Laboratory
USB	Universal Serial Bus

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45433-7604

1 USN ONR
(PDF) ONR CODE 341 J TANGNEY
875 N RANDOLPH STREET
BLDG 87
ARLINGTON VA 22203-1986

1 USA NSRDEC
(PDF) RDNS D D TAMILIO
10 GENERAL GREENE AVE
NATICK MA 01760-2642

1 OSD OUSD ATL
(PDF) HPT&B B PETRO
4800 MARK CENTER DRIVE
SUITE 17E08
ALEXANDRIA VA 22350

ABERDEEN PROVING GROUND

13 DIR USARL
(PDF) RDRL HR
J LOCKETT
P FRANASZCZUK
K MCDOWELL
K OIE
RDRL HRB
D HEADLEY
RDRL HRB C
J GRYNOVICKI
M GEUSS
J CAMPANELLI
RDRL HRB D
C PAULILLO
RDRL HRF A
A DECOSTANZA
RDRL HRF B
A EVANS
RDRL HRF C
J GASTON
RDRL HRF D
A MARATHE

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